Report to

Department of the Army
New England Division
CORPS OF ENGINEERS

Benthic Algae and Fauna of Clinton Harbor, CT

June, 1982

Taxon, Inc.
50 Grove St.
Salem, MA 01970

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Department of the Army

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CORPS OF ENGINEERS

on

Amendment No. 1 to

Contract DACW 33-81-C-0116

Mr. G. L. Chase
Contract Monitor
Impact Analysis Branch

Environmental Baseline Data Collections and Site Evaluations
Long Island Sound Container Disposal Study

Benthic Algae and Fauna of Clinton Harbor, CT
June, 1982

Richard A. McGrath
Walter F. Grocki

August 1982

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50 Grove St.
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1.0. INTRODUCTION

This document presents the results of an environmental survey of soft and hard bottom benthic communities performed under Amendment No. 1 to Contract No. DACW33-81-C-0116 to Taxon, Inc. This work is a continuation of a multi-disciplinary environmental baseline data collection and site evaluation performed in September - October, 1981 (McGrath, et al., 1982).

The purpose of the present study was to document existing conditions in the benthic infaunal communities of the proposed container disposal area during the spring season; all three previous inventories in this area (Pellegrino and Baker, 1975(?); McGrath, et al., 1978; McGrath, et al., 1982) were conducted in the Fall. It was felt that some additional sampling was necessary to assess seasonal variation in the composition of the fauna.

In addition, a sampling of local hard (rock) bottom algae and fauna was included in order to evaluate the type of community which will develop on the outer face of the rock containment structure as it is presently proposed (Garbisch, 1982). Littoral hard-bottom communities have been shown to be both more dense and diverse than infaunal communities in the same area and it is believed that this will ameliorate, to some degree, the removal from the Clinton Harbor system of a large area of soft bottom habitat due to emplacement of the disposal area.

2.0. METHODS

Sampling for this phase of the Clinton Harbor Baseline Data Collection and Site Evaluation was conducted on 3 June 1982. All sampling was performed in accordance with the provisions of Job Change No. 1 to Contract DACW33-81-C-0116.

2.1. Field

Nine of the 16 stations occupied during September and October, 1981 were selected for resampling during the spring of 1982 (Figure 1). Two replicate $0.04m^2$ samples were collected at each station with a modified Van Veen grab, placed in muslin bags, and preserved in drums of buffered 10% seawater formalin. Station locations were established via ranges and azimuths on fixed landmarks and distance measurements using a parallax-type rangefinder. Complete station locations are provided by McGrath (1982).

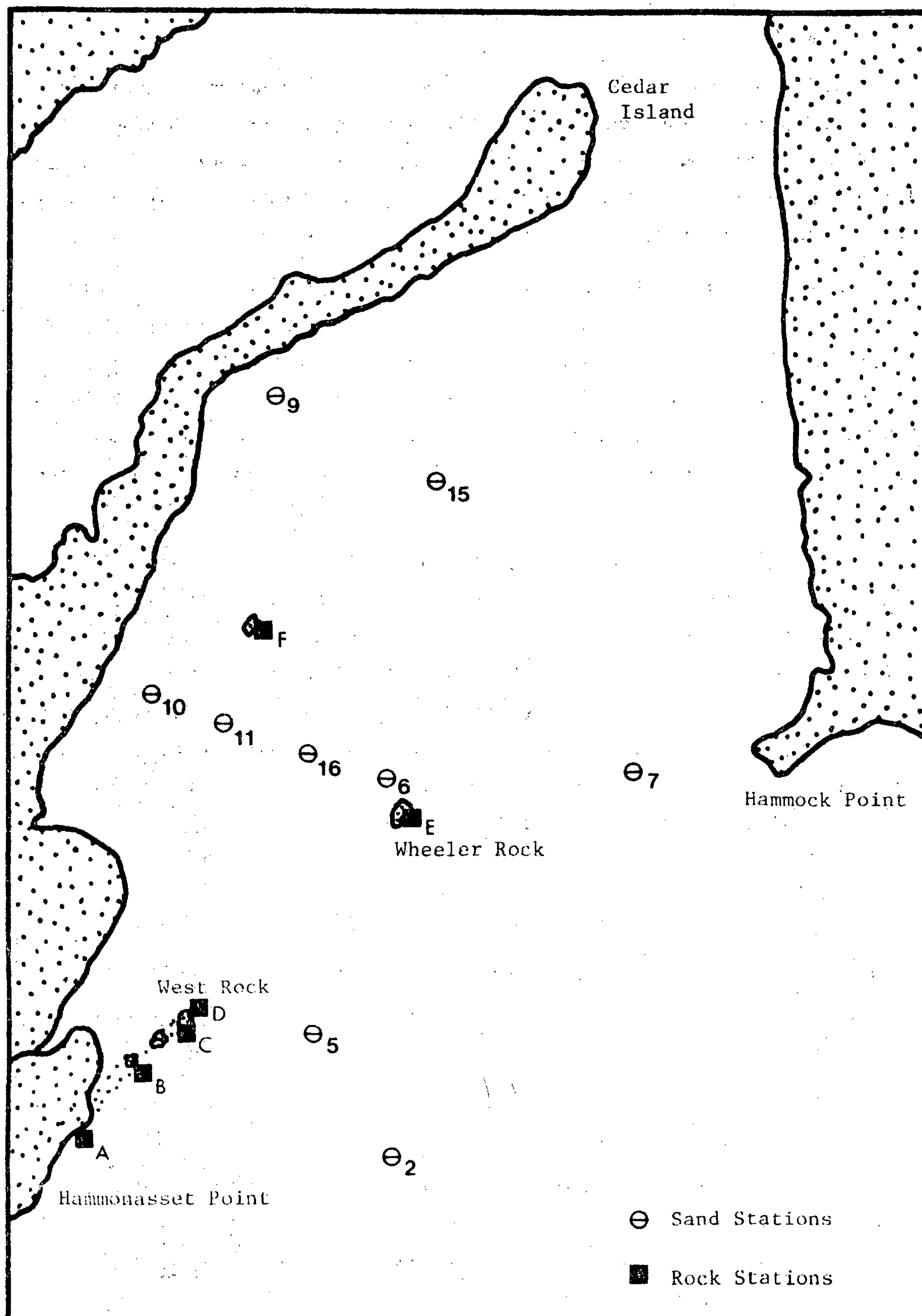

Figure 1: June, 1982 sampling locations.

At each of the six rock stations (Figure 1), two replicate $0.1m^2$ samples were collected by divers using the air-lift collection device shown in Figure 2. A $33cm^2$ pipe-frame quadrat was placed on the rock and all algal and faunal material within the quadrat was scraped off the rock surface and suctioned into a 0.5mm nylon mesh collection bag attached to the air-lift. Upon return to the surface, the nylon bags were sealed and preserved in drums of buffered 10% seawater formalin.

We attempted to restrict the elevation of the rock substratum samples to the area immediately below the zone which is exclusively barnacles, or to approximately -.5m (MLW). This was not possible in the case of Station E (Wheeler Rock) which is entirely below this elevation or Station F, which is entirely above it. Although this variation tends to make strict comparisons between the rock stations more difficult, it does simulate, to some extent, the range of habitats to be expected on the proposed containment breakwater.

2.2. Laboratory

All samples were returned to and analyzed at our laboratory in Salem, Massachusetts. Following fixation in formalin for 48 hours, the grab samples were sieved through 0.5mm stainless-steel sieves and stored in 70% isopropanol. Rock substratum samples were washed and the algal and faunal material separated by eye in enameled basins. Faunal material was stored in 70% isopropanol and subsequently treated in the same manner as the grab samples. Algal material was maintained in a 5% formalin solution prior to processing.

Faunal samples were analyzed via a two-step procedure (presorting, separation of fauna from residual material and final sorting, identification and enumeration of the component fauna); identifications were made at the species level whenever the condition of the specimen and current taxonomic practices permitted. Algal material was identified to species when possible. Algal biomass for each species was determined by drying the algal material at 70°C for 48 hrs. and weighing on a top-loading analytical balance.

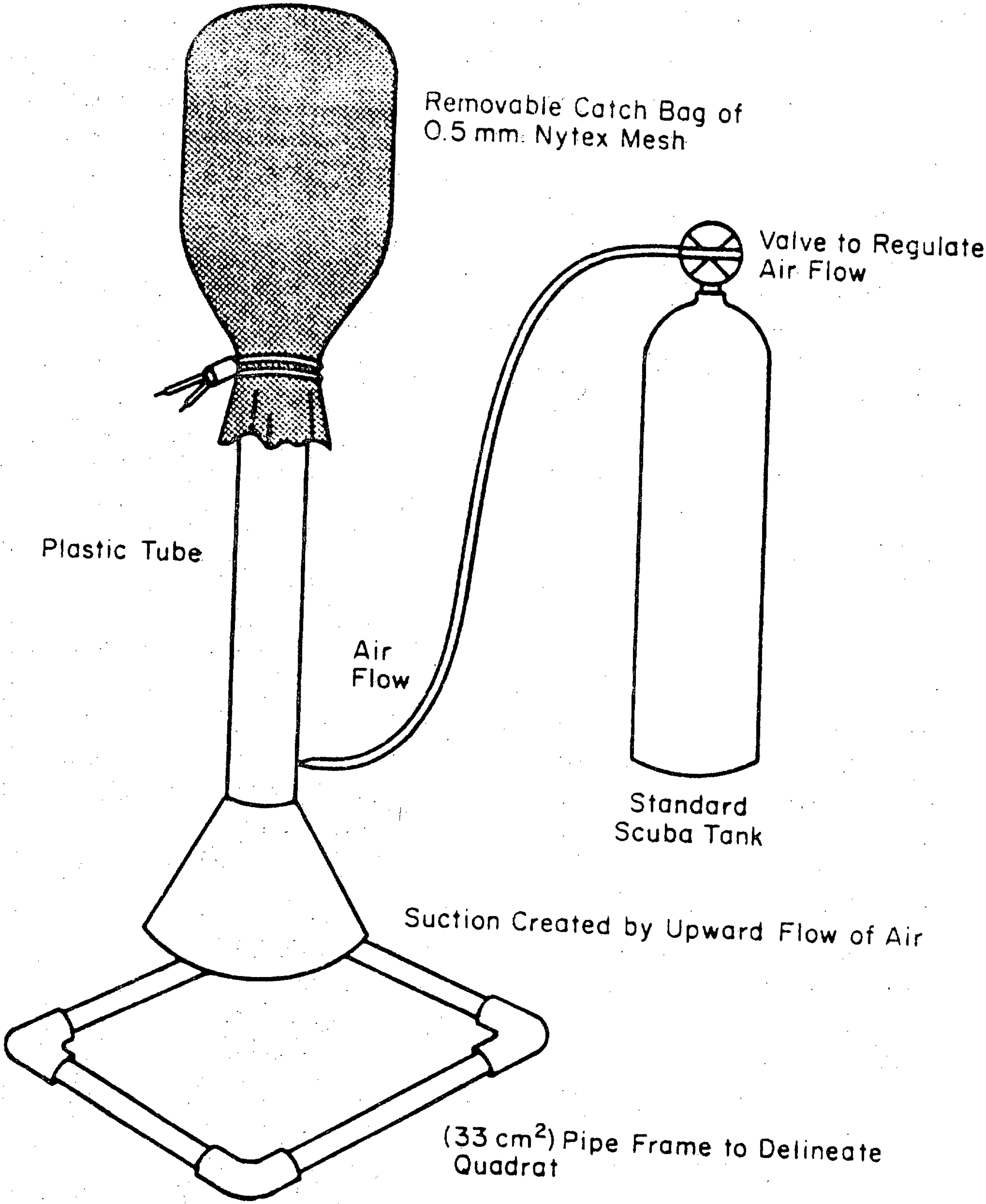

FIGURE 2. *Rock substratum airlift sampling device.*

2.3. Data Analysis

Faunal data was entered into the Woods Hole Oceanographic Institution's VAX/11-780 computer and analyzed using a suite of programs originated at WHOI specifically for benthic faunal data. These included PRARE1 (diversity calculations and data listing), PERSORT (abundance rankings), and SPSTCL (classification analysis).

Diversities were calculated using the Shannon-Wiener formula:

$$H' = -\sum p_i \ln p_i,$$

where p_i is the proportion of the ith species in the sample. The similarity coeffient used for the classification analysis was the Bray-Curtis similarity index:

$$\sum_{AB} \mathrm{MIN} \left[\frac{N_i^A}{N^A} , \frac{N_i^B}{N^B} \right]$$

which is calculated as the sum, over all species in common between two samples, of the smaller of the two percentages at which the species occurs in the two samples. The clustering strategy selected was unweighted pair-group using arithmetic averages (UPGMA). Both methods have seen wide application in ecological studies (Boesch, 1977).

3.0. RESULTS

3.1. The Sand Substratum Fauna

The spring benthic faunal communities show marked similarity to those described from the Fall, 1981 collections but there are also some obvious differences due to a combination of seasonal (or longer-term) variation and random variation inherent in natural populations. A complete taxonomic list of the species and/or taxa collected in June at Clinton Harbor is presented in Table 1. Of the 90 species found at the sand stations, nearly all were also present in previous collections (McGrath, et al., 1982).

The most obvious changes in the sand fauna between the two seasons are in the dominance patterns. In September - October 1981, the polychaete *Streblospio benedicti* was the most common infaunal species in the study area; in the recent collection, *Streblospio* was present in less than 75%

Table 1: Species list from June, 1982 sampling of Clinton Harbor. Species within each taxonomic group are arranged in approximate order of abundance.

MOLLUSCA

Tellina agilis
Mytilis edulis
Gemma gemma
Lacuna vincta
Mitrella lunata
Nassarius trivittatus
Crepidula fornicata
Littorina littorea
Petricola pholadiformis
Urosalpinx cinerea
Anachis translirata
Crepidula plana
Mulinia lateralis
Onchidoris aspera
Bittium alternatum
Hiatella arctica
Nucula annulata
Anomia simplex
Nucula delphinodonta
Anomia aculeata
Turbonilla elegantula
Lunatia sp.
Spisula solidissima
Margarites umbilicalis
Anadara transversa
Gastropoda
Ilyanassa obsoleta
Odostomia gibbosa
Turbonilla nivea

ECHINODERMATA

Amphipholis squamata

MISCELLANEOUS

Nemertea
Metridium senile
Turbellaria
Euplana gracilis
Sipunculoidea

CRUSTACEA

Jassa falcata
Corophium bonelli
Corophium acutum
Marinogammarus stoerensis
Calliopius laevisculus
Balanus improvisus
Caprella penantis
Neopanope sayi
Aeginina longicornis
Erichsonella filiformis
Erichthonius brasiliensis
Idotea balthica
Ostracoda
Pagurus longicarpus
Leucon americanus
Idotea phosphorea
Unciola serrata
Edotea triloba
Leptochelia savignyi
Corophium simile
Paraphoxus spinosus
Trichophoxus epistomus
Oxyurostylis smithi
Cancer irroratus
Elasmopus levis
Phoxichilidium femoratum
Gammarus oceanicus
Cyathura polita
Phoxocephalus holbolli
Monoculodes edwardsi
Caprellidae
Decapoda
Jaera marina
Pseudoleptocuma minor
Libinia dubia
Tanystylum orbiculare
Photis sp.
Stenothoe minuta
Ampelisca abdita
Cumacea
Proboloides holmesi

Table 1 (cont.)

ANNELIDA

Scolecolepides viridis	Archiannelida
Tharyx acutus	Capitella capitata
Oligochaeta	Polydora ligni
Asabellides oculata	Eumida sanguinea
Harmothoe imbricata	Parapionosyllis longicirrata
Streblospio benedicti	Eteone lactea
Glycera americana	Nicolea venustula
Mediomastus ambiseta	Nereis sp.
Syllinae/Eusyllinae	Clymenella torquata
Prionospio steenstrupi	Pygospio elegans
Polygordius spp.	Pholoe minuta
Exogone sp.	Polydora commensalis
Autolytus sp.	Lepidonotus squamatus
Polydora aggregata	Ampharetidae
Sabellaria vulgaris	Nereidae
Nereis pelagica	Aricidea cerruti
Spiophanes bombyx	Polychaeta unid.
Autolytus cornutus	Cirratulidae
Paraonis fulgens	Hydroides dianthus
Fabricia sabella	Drilonereis longa
Marphysa sanguinea	Spionidae
Odontosyllis sp.	Dodecaceria corali
Aricidea catharinae	Capitellidae
Nephtys picta	Peloscolex benedeni
Phyllodocidae	Sphaerodoropsis minuta
Eteone heteropoda	Potamilla sp.
Polycirrus eximius	Nereis zonata
Nephtys incisa	Sigalionidae
Nephtydae	Hesionidae
Potamilla reniformis	Scoloplos acutus
Anaitides groenlandica	Dorvilleidae
Orbiniidae	Cirratulus grandis
Pista palmata	Anaitides mucosa
Autolytus fasciatus	Polydora caulleryi
Maldanidae	Nereis arenaceodonta
Sabella microphthalma	Spio filicornis

of the samples (Table 2). Conversely, a suite of amphipod species (Jassa falcata, Corophium acutum and C. bonelli, and Marinogammarus stoerensis) which were present as dominants in the recent collection, appear infrequently in the earlier study. Some species, including the bivalve Tellina agilis, the polychaete Tharyx acutus, and the Oligochaetes were dominants in both collections and can probably be regarded as the more stable and continuous faunal species in the harbor.

Species richness among the sand substratum stations (Table 3) varied from a low of 13 taxa at Station 7-2 to a high of 30 taxa at Station 16-1 ($\bar{x}$ = 19.9 species/0.04m^2). These values were generally higher than those from the Fall collections, probably due to an influx of transient species from planktonic dispersal of the larvae of spring-spawning benthic species.

Faunal densities (Table 3), extrapolated to numbers of individuals per square meter, varied from 1500/m^2 to 35,650/m^2 ($\bar{x}$ = 8,968/m^2). These values are generally higher than those from the September - October collections and are again probably indicative of the effect of spring-spawning species.

Shannon-Wiener diversity values (H') (Table 3) were also generally higher and somewhat more stable throughout the area in the recent collections, particularly in comparison with the data from September, 1981. The mean diversity value (2.71) is essentially equal to that recorded in October, 1981 (2.70).

3.2. The Rock Substratum Fauna

One of the purposes of the present study was to document the characteristics of the resident hard-bottom benthos in the harbor in order to develop an understanding of the type of community which would be expected to develop on the proposed containment breakwater. The data indicate that such a community would be richer in both density and diversity than the present soft-bottom community, and would share many of the same species.

The dominant species in the rock substratum benthic community were generally of three types: (1) species which attach to the substratum and are absolutely restricted to hard bottom; (2) species which depend upon attached macro- and micro-algae as a food source and are more-or-less

Table 2: Most commonly occurring species at rock and sand stations.

Sand Substratum		Rock Substratum	
Species	% Occurrence	Species	% Occurrence
Tellina agilis	100.0	Jassa falcata	100.0
Jassa falcata	100.0	Corophium acutum	100.0
Tharyx acutus	88.9	Mytilis edulis	100.0
Scolecolepides viridis	83.3	Lacuna vincta	100.0
Corophium acutum	77.8	Corophium bonelli	100.0
Corophium bonelli	77.8	Harmothoe imbricata	91.7
Streblospio benedicti	72.2	Calliopius laevisculus	83.3
Gemma gemma	72.2	Balanus improvisus	83.3
Oligochaeta	61.1	Marinogammarus stoerensis	75.0
Marinogammarus stoerensis	61.1	Mitrella lunata	75.0
Asabellides oculata	55.6	Caprella penantis	58.3
Glycera americana	55.6	Neopanope sayi	58.3
Mediomastus ambiseta	55.6	Nereis pelagica	58.3
		Polydora aggregata	58.3

Table 3: Species richness, faunal density, and diversity by replicate for June, 1982 Clinton Harbor sampling.

Sample	# Species	# Individuals	$\#/m^2$	Diversity
2-1	15	60	1500	3.29
2-2	19	71	1775	3.73
5-1	18	314	7850	2.50
5-2	17	184	4600	2.62
6-1	22	367	9175	2.63
6-2	21	368	9200	2.86
7-1	25	206	5150	3.22
7-2	13	63	1575	2.79
9-1	22	356	8900	3.04
9-2	28	451	11275	3.11
10-1	16	186	4650	3.34
10-2	18	1426	35650	1.80
11-1	19	852	21300	1.07
11-2	17	547	13675	1.09
15-1	27	428	10700	2.53
15-2	15	222	5550	2.36
16-1	30	245	6125	3.72
16-2	16	111	2775	3.05
$\bar{x}$	19.9	358.7	8968	2.71
A-1	30	8804	80,845	1.17
A-2	20	13,930	127,916	1.24
B-1	35	3200	29,385	2.29
B-2	53	1718	15,776	3.33
C-1	18	28,384	260,643	1.49
C-2	14	11,344	104,169	1.58
D-1	22	4614	42,369	2.25
D-2	18	7106	65,253	1.69
E-1	40	2503	22,984	3.80
E-2	47	3642	33,444	3.98
F-1	29	484	4444	3.28
F-2	24	979	8990	2.73
$\bar{x}$	29.2	7225.6	66,352	2.40

restricted to hard bottoms; and (3) species which utilize the "detrital trap" provided by the macroalgae to augment their feeding and thereby reach maximum densities on hard bottoms though they are not absolutely restricted to them.

Dominant species in the first category on rock substratum in the Clinton Harbor system include the blue mussel, Mytilis edulis and the barnacle, Balanus improvisus. Both species compete with each other and other attached biota for space, which is a limiting resource in this type of habitat. This, combined with various sources of predation, produces pronounced seasonality in populations of these species. During the June, 1982 sampling, extremely dense populations of barnacles were present at many stations, but this may not necessarily be typical for the area.

Dominant species of the second type noted above included the two gastropods Lacuna vincta and Mitrella lunata. These species are a common and persistent component of shallow hard bottom communities in New England. The third type of species described above was represented at Clinton by the amphipods Jassa falcata, Corophium acutum and C. bonelli. Although these species were also ubiquitous throughout the sandy areas of the harbor, the densities seen at the rock sites were far greater than those seen in the sand areas.

As was anticipated, species richness and faunal density were greater at the rock stations than at the sand stations. Species richness (Table 3) varied from 14 to 53 species/0.1m^2 and, although this cannot be compared directly to the data for the sand stations because of the unequal sample sizes, the increase of nearly 50% per sample was greater than can be attributed to sample size alone.

The increase in faunal density, which can be normalized to individuals/m^2 and compared directly between habitats, was even more striking (Table 3). The mean density at the rock stations (66,352/m^2) was over seven times greater than that recorded from the sand substratum. The greatest density recorded from the rock samples was also over seven times greater than the highest recorded sand density (260,643/m^2 vs. 35,650/m^2).

Diversities at the rock stations were generally lower than those recorded from the sand (Table 3). This is due to the tendency in such habitats of a single species to temporarily outcompete others for available resources (e.g. space) and thereby establish extremely high densities. As noted above, for the present study this was particularly obvious for Balanus improvisus. The effect of this upon diversity is to produce lower values because the Shannon formula is overly sensitive to the proportional representation of the species.

3.3. Community Classification

The results of a normal, or Q-mode, classification analysis are presented in the form of a heirarchical dendrogram in Figure 3.

The most apparent dichotomy in the dendrogram is the clear and complete separation between the sand and rock stations. No rock station clustered with the sand group, and vice-versa; the two groups join only at very low levels of similarity. Although this result is hardly surprising in light of the previous discussion and even a casual examination of the data, it does graphically demonstrate the profound effect of substratum type on the structure of the benthic faunal community. Since, in some cases, these rock and sand communities co-exist less than 100m from each other, they share the same physical regime except for substratum.

Considering the groupings within each substratum cluster, the sand stations 5, 11, and 15 form a cluster which is apparently due to the presence of the polychaete Scolecolepides viridis as a dominant species with the amphipod Jassa falcata as a sub-dominant. High proportional densities of Scolecolepides were restricted to these three stations, which do not form a contiguous identifiable zone within the harbor (Figure 4).

A second group within the sand substratum cluster includes stations 6 and 7 and one of the replicates at station 2. This cluster includes stations which were dominated by Streblospio benedicti and Tellina agilis with Scolecolepides also present as a sub-dominant in most cases. This faunal group appears to be similar in composition to group III as identified from the September, 1981 samples and to groups IV and VI from the October samples, and, in its various forms, appears to be the most representative assemblage of the harbor. Stations 10 and 16 in June were

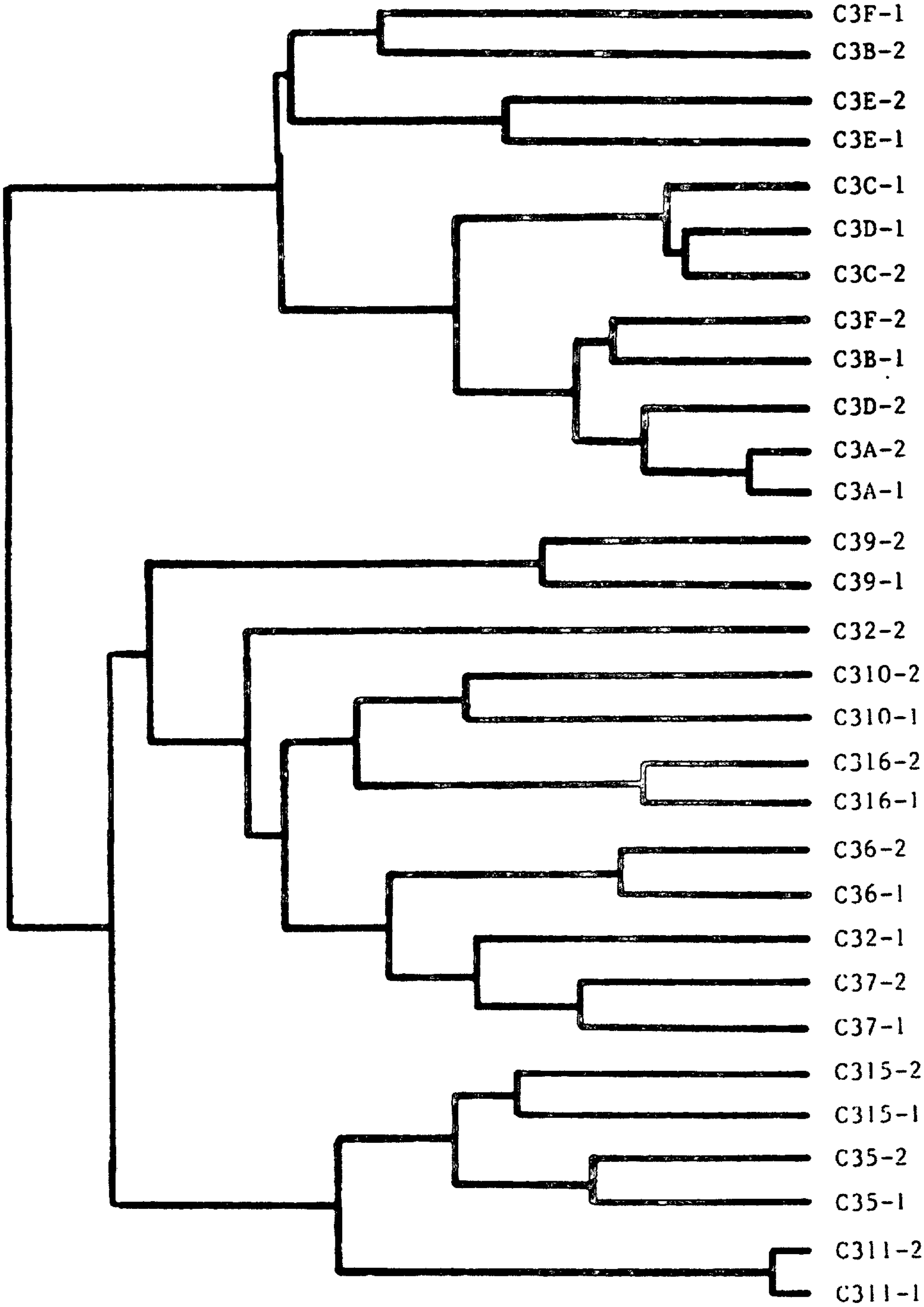

Figure 3: Heirarchichal dendrogram showing relationships among stations sampled in June, 1982, at Clinton Harbor.

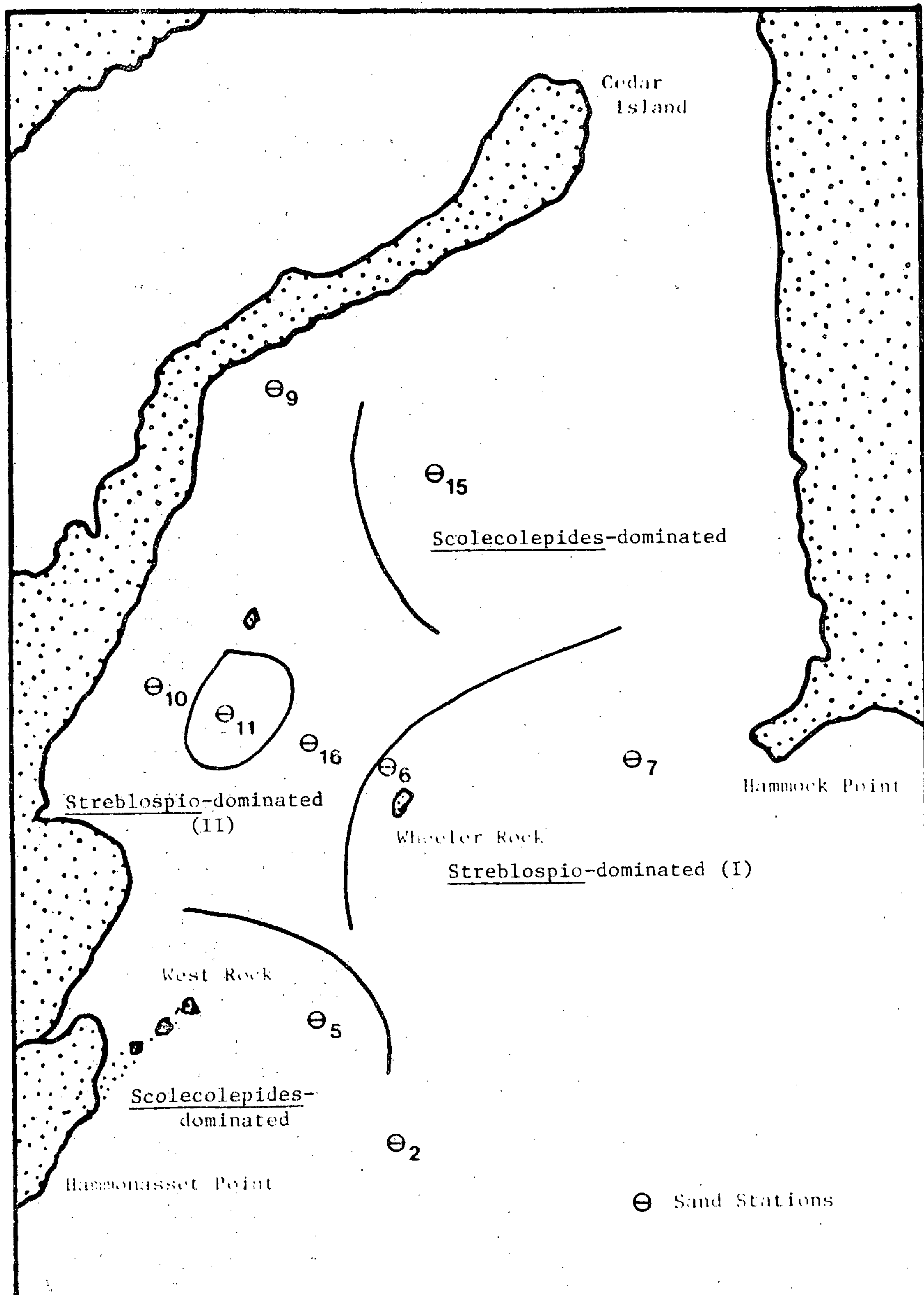

Figure 4: Community type distribution in June, 1982 at Clinton Harbor.

closely related to this cluster, differing primarily in the proportional representation of such species as *Pygospio elegans* and *Gemma gemma*. Considered together, this cluster physically occupies a large area of the central harbor (Figure 4).

Within the rock cluster, the primary dichotomy is between Station E and one replicate each from Stations B and F, and the remainder of the samples. This is directly attributable to the proportional representation of barnacles at these sites. Station E, at Wheeler Rock, was necessarily sampled below the barnacle zone. The other two samples, although barnacles were present, do not show the degree of dominance by this species which is characteristic of the other samples. This is presumably due to small-scale patchiness caused by microhabitat variation or predation.

All the remaining rock stations were strongly dominated by *Balanus improvisus* but were separated into two groups according to their sub-dominants. The group which included both replicates from Station A plus single replicates from Stations B, D, and F was characterized by dense populations of the gastropods *Mitrella* and *Lacuna*. The remaining small group was characterized by dense populations of detritovorous amphipods (*Jassa* and *Corophium* spp.).

With the exception of Station E (Wheeler Rock) the reason for the differences among the rock stations is not clear. Presumably, minor and essentially unnoticeable differences in microclimate and exposure are sufficient to produce more substantial changes in the resident fauna in such communities.

4.0. RESULTS (ALGAE)

4.1. Species Richness

A total of 40 algal species was recorded from the six Clinton Harbor subtidal rock-substratum stations (Table 4). Species richness was moderately high and generally uniform for all stations and replicates throughout the survey area (Table 5). No single station or replicate contained all 40 species. The number of species contained in the individual replicates showed moderate variation, ranging from a minimum of 10 to a maximum of 22; the mean number of species per replicate was 15.6. The total number of species recorded for each station showed somewhat less

Table 4. Algal species occurrence and biomass (g/m^2) from the replicate samples of the Clinton Harbor rock substratum stations.

Division Species	Station and Replicate A 1	A 2	B 1	B 2	C 1	C 2	D 1	D 2	E 1	E 2	F 1	F 2
Green algae (Chlorophyta)												
Chaetomorpha linum	-	P	-	-	-	-	-	-	-	-	-	-
Cladophora albida	-	-	-	-	-	-	-	-	P	-	-	-
Cladophora glaucescens	-	-	-	-	-	-	-	-	-	P	-	-
Cladophora ssp.	-	P	-	-	-	-	-	-	-	-	P	-
Enteromorpha clathrata	-	-	-	P	-	-	-	-	-	-	-	P
Enteromorpha flexuosa	P	-	-	P	-	P	-	-	-	-	-	P
Enteromorpha intestinalis	-	P	-	-	-	-	-	-	-	-	-	-
Enteromorpha linza	-	P	-	-	P	P	P	P	-	P	-	P
Enteromorpha spp.	-	P	-	P	-	-	P	-	-	-	-	P
Monostroma grevillei	P	10.1	P	P	1.5	P	P	P	-	P	P	-
Spongomorpha aeruginosa	-	-	-	-	P	-	-	-	-	-	-	-
Spongomorpha arcta	-	-	P	-	-	P	P	-	P	P	-	-
Ulothrix flacca	-	-	-	-	-	-	-	-	-	-	-	P
Ulva lactuca	P	P	P	P	6.7	12.0	11.9	25.3	P	P	P	P
Brown algae (Phaeophyta)												
Desmarestia aculeata	-	-	-	-	-	-	-	-	-	P	-	-
Desmarestia viridis	-	-	P	P	P	P	-	-	P	P	-	-
Ectocarpus confervoides	-	P	-	-	1.3	P	1.4	P	P	5.1	-	-
Giffordia granulosa	-	-	-	-	-	-	-	-	-	P	-	-
Laminaria saccharina	P	P	-	-	9.1	1.1	8.8	48.3	46.3	37.6	-	P
Petalonia fascia	3.5	4.9	-	-	P	P	P	P	-	-	P	P
Pilayella littoralis	-	-	P	P	19.6	21.1	22.5	20.0	4.3	P	-	-
Punctaria latifolia	-	P	-	-	-	-	-	-	-	-	-	P
Scytosiphon lomentaria	3.5	30.4	-	-	3.8	P	P	P	-	P	P	-

Table 4. (continued)

Division Species	Station and Replicate A 1	 2	 B 1	 2	 C 1	 2	 D 1	 2	 E 1	 2	 F 1	 2
Red algae (Rhodophyta)												
Ahnfeltia plicata	1.3	P	-	-	P	P	-	P	P	-	-	-
Antithamnion cruciatum	-	-	-	-	-	-	-	-	P	P	-	-
Callithamnion roseum	-	-	-	-	P	P	P	-	P	P	-	-
Ceramium rubrum	-	-	-	P	18.0	6.0	7.7	P	P	P	P	P
Chondrus crispus	229.1	270.1	916.3	706.1	393.8	316.6	307.4	298.5	-	P	353.0	583.3
Cystoclonium purpureum	P	-	P	P	-	P	P	P	2.3	1.7	1.5	P
Dumontia incrassata	-	-	-	P	-	-	-	-	-	-	10.0	86.1
Goniotrichum alsidii	-	-	-	-	-	-	-	-	-	-	-	P
Gracilaria foliifera	-	-	-	-	-	-	-	-	-	P	-	-
Palmaria palmata	-	P	-	-	-	-	7.6	-	-	-	-	-
Phyllophora truncata	P	-	-	-	-	-	-	1.9	466.6	520.8	-	-
Polysiphonia denudata	-	P	-	-	-	-	-	-	-	-	-	-
Polysiphonia harveyi	P	-	-	-	P	P	-	-	-	P	P	-
Polysiphonia nigrescens	P	-	P	P	-	-	P	-	P	P	-	P
Polysiphonia urceolata	-	P	P	P	106.6	58.5	51.5	3.1	P	P	P	-
Porphyra leucosticta	P	1.6	P	-	2.2	2.5	1.9	P	-	-	-	-
Rhodomela confervoides	-	-	-	-	-	-	-	-	-	-	-	P

Legend: - = not present; P = biomass less than 1g/m^2

Table 5. Algal species richness and community structure from the samples of the Clinton Harbor rock substratum stations a) by replicate, and b) by station.

a) By replicate

Station and replicate	Chlorophyta (green algae)	Phaeophyta (brown algae)	Rhodophyta (red algae)	Species richness
A,1	3 (23%)	3 (23%)	7 (54%)	13
A,2	7 (39%)	5 (28%)	6 (33%)	18
B,1	3 (30%)	2 (20%)	5 (50%)	10
B,2	5 (39%)	2 (15%)	6 (46%)	13
C,1	4 (24%)	6 (35%)	7 (41%)	17
C,2	5 (26%)	6 (32%)	8 (42%)	19
D,1	5 (28%)	5 (28%)	8 (44%)	18
D,2	3 (20%)	5 (33%)	7 (47%)	15
E,1	3 (20%)	4 (27%)	8 (53%)	15
E,2	5 (23%)	7 (32%)	10 (45%)	22
F,1	3 (27%)	2 (18%)	6 (55%)	11
F,2	6 (37%)	3 (19%)	7 (44%)	16

b) By station

Station	Chlorophyta (green algae)	Phaeophyta (brown algae)	Rhodophyta (red algae)	Species richness
A	8 (35%)	5 (22%)	10 (43%)	23
B	6 (40%)	2 (13%)	7 (47%)	15
C	6 (30%)	6 (30%)	8 (40%)	20
D	5 (25%)	5 (25%)	10 (50%)	20
E	6 (25%)	7 (29%)	11 (46%)	24
F	8 (38%)	4 (19%)	9 (43%)	21

variation, ranging from a low of 15 at Station B to a high of 24 at Station E; the mean number of species recorded at each station was 20.5.

The number of species representing each of the major algal divisions was also similar for all six stations (Table 5). Red algal species (Rhodophyta) predominated throughout the survey area, comprising between 40 and 50% of the total species number at the individual stations. Green algal species (Chlorophyta) and brown algal species (Phaeophyta) were less well represented; green algae accounted for between 25 and 40% of the total species number at each station, while brown algal composition ranged between 13 and 30%.

4.2. Community Overlap

Community overlap analyses, which provide a measure of the degree of similarity in species composition between stations, were performed using Jaccard's Coefficient of Community (Grieg-Smith, 1964). The results (Table 6) showed overlap to be moderately high and relatively uniform for all station pairs, ranging from a low of 26.7% to a high of 66.7%; the average overlap value was 46.7%. These data indicate that algal species composition was generally uniform throughout the six-station survey zone.

4.3. Species Dominance and Community Structure

Assessments of algal species dominance and community structure for all stations were based upon biomass determinations. Replicate biomass values are included in Table 4 for each species displaying biomass of 1 g/m^2 or greater. Table 7 lists the mean station biomass value for all species with biomass greater than 1 g/m^2 in at least one replicate. The tables show that dense populations of the red algal benthic macroscopic carrageenoids *Chondrus crispus* and *Phyllophora truncata* dominated all six stations. *Chondrus* was the dominant taxa at all stations except E, with biomass ranging from 249.6 g/m^2 at Station A to 811.2 g/m^2 at Station B. *Chondrus*' dominance is further illustrated by viewing *Chondrus* biomass as a proportion of total algal biomass at each station (Table 7). *Chondrus* biomass is seen to comprise between 72% (Station C) and 99% (Station B) of total station biomass at the five locations. Station E (Wheeler Rock) was dominated by *Phyllophora*, which showed biomass of 493.7 g/m^2 and accounted for 91% of the total station biomass. The replacement of *Chondrus* by *Phyllophora* at Station E is primarily a function of depth; Station E

Table 6. Community overlap (Jaccard's Coefficient of Community) between the Clinton Harbor rock substratum stations.

Station pair	number of shared species	community overlap
A/B	8	26.7%
A/C	14	48.3%
A/D	16	59.3%
A/E	13	38.2%
A/F	15	51.7%
B/C	11	45.8%
B/D	11	45.8%
B/E	10	34.5%
B/F	11	44.0%
C/D	16	66.7%
C/E	16	57.1%
C/F	12	41.4%
D/E	16	66.7%
D/F	12	41.4%
E/F	11	32.4%
Mean value	12.8	46.7%

Table 7. Algal biomass (g/m^2) and percent composition of the dominant species from the Clinton Harbor rock substratum stations.

Species	Station A	Station B	Station C	Station D	Station E	Station F
Chondrus crispus	249.6 (90%)	811.2 (99%)	355.2 (72%)	302.9 (73%)	P	468.1 (90%)
Phyllophora truncata	P	-	-	1.0 (<1%)	493.7 (91%)	-
Laminaria saccharina	P	-	5.1 (1%)	28.5 (7%)	41.9 (8%)	P
Ulva lactuca	P	P	9.4 (2%)	18.6 (5%)	P	P
Pilayella littoralis	-	P	20.3 (4%)	21.3 (5%)	2.2 (<1%)	P
Scytosiphon lomentaria	16.9 (6%)	-	1.9 (<1%)	P	P	P
Polysiphonia urceolata	P	P	82.5 (17%)	27.3 (7%)	P	P
Ceramium rubrum	-	P	12.0 (2%)	3.9 (1%)	P	P
Dumontia incrassata	-	P	-	-	-	48.0 (9%)
Porphyra leucosticta	0.8 (<1%)	P	2.4 (1%)	1.0 (<1%)	-	-
Cystoclonium purpureum	P	P	P	P	2.0 (<1%)	0.8 (<1%)
Ectocarpus confervoides	P	-	0.7 (<1%)	0.7 (<1%)	2.6 (1%)	-
Monostroma grevillei	5.1 (2%)	P	0.8 (<1%)	P	P	P
Ahnfeltia plicata	0.7 (<1%)	-	P	P	P	-
Petalonia fascia	4.2 (2%)	-	P	P	-	P
Palmaria palmata	P	-	-	3.8 (1%)	-	-
All other species	1.2 (<1%)	2.9 (1%)	1.8 (<1%)	3.7 (1%)	1.4 (<1%)	0.8 (<1%)
Total algal biomass	278.5	814.1	492.1	412.7	543.8	517.7

Legend: - = not present; P = biomass less than 1g/m^2.

(-8' MLW) is particularly well suited for colonization by Phyllophora, which is known to achieve maximal growth and density in waters of moderate depth.

Benthic species other than Chondrus and Phyllophora were poorly represented at all six stations due to an overall inability to successfully compete with the dominant carrageenoids. The benthic species Laminaria saccharina, Ulva lactuca, Scytosiphon lomentaria, Monostroma grevillei, and Petalonia fascia were recorded from the majority of stations (Tables 4,7). However, biomass for each species did not exceed 50 g/m^2 at any station, and was considerably less at most. The percent composition for each species was likewise reduced, with the biomass of each species not exceeding 10% of total algal biomass at any station.

Epiphytic algal populations were present in varying degrees of abundance at all six stations, with Chondrus and Phyllophora serving as the principal host species. The epiphytic populations were most well developed at stations C and D, least well developed at station A, B, and F, and of average development at station E (Table 7). The dominant epiphytic species, which were recorded from the majority of stations, were Pilayella littoralis, Ceramium rubrum, Cystoclonium purpureum, Ectocarpus confervoides, and Polysiphonia urceolata. Although the epiphytic species contributed substantially to overall species richness at all stations throughout the survey area, they contributed only minimally towards station biomass; epiphytic species biomass exceeded 100 g/m^2 only at station C, and did not exceed 25% of total algal biomass at any stations.

4.4. Algal Biomass

As biomass data for the individual species has been addressed in the previous section, only total station biomass will be considered here. Total station biomass showed considerable variation, ranging from a low of 278.5 g/m^2 at station A to 814.1 g/m^2 at station B; the mean station biomass for the entire six station survey area was 509.8 (Table 7). All values are similar to those recorded for similar habitats throughout New England.

5.0. DISCUSSION AND CONCLUSIONS

Although it is not possible to address seasonality in the Clinton Harbor infauna on the basis of essentially two seasonal collections, we now know that the benthic communities in the proposed container disposal area do not appear to change radically between Spring and Fall. The results of this survey indicate that most of the species which have been described as important faunal components in previous collections are also present in the Spring but that, in some cases, their positions as dominants in the community are taken over by other related species.

The actual taxonomic composition of the infaunal communities on a seasonal basis is probably of less importance for the Clinton Harbor system than the community parameters of species richness, faunal density, and diversity. If we view the benthos as secondary producers whose role in the ecosystem is to convert energy into forms which become available to higher trophic levels, then it is apparent that, in general, the seasonal change from dominance by one species to dominance by another related species (for example, from Streblospio to Scolecolepides in the present case) is of less significance than large changes in the numbers of organisms present.

When viewed from this perspective, the amount of seasonality evident at Clinton is minimal. The present collections indicate moderate increases in species richness and faunal density in these infaunal communities but these changes are not of sufficient magnitude to alter the functional relationships between the benthos and other components of the ecosystem.

The resident hard bottom biotic community at Clinton Harbor is typical of such habitats throughout New England. The red algal species Chondrus crispus and Phyllophora truncata (collectively harvested in some areas as Irish moss) were the dominant algae at all sites and both the algal and faunal components of this habitat had elevated species diversity and standing stocks.

The ecological value of this type of community is multifaceted. The high algal density produces a zone of benthic primary production which is essentially absent from soft bottom communities. The physical nature of the algal cover, particularly the dense mat produced by Chondrus and Phyllophora creates an ideal breeding and foraging habitat for many faunal species producing much greater population densities than would otherwise be possible. The creation of additional habitat of this kind at Clinton would be one of the unquestionalble benefits of the proposed container disposal construction.

In comparison to a similar Long Island Sound hard bottom community for which similar data are available, Black Ledge - New London Harbor (McGrath et al., 1982a), the algal populations at Clinton were found to be of considerably greater ecological value. Algal populations at Black Ledge were adversely impacted by a dense population of mussels (Mytilis edulis) which prevented the establishment of a healthy Chondrus/Phyllophora community. Although this resulted in greater algal species diversity, the increase was among the small epiphytic species which do not contribute significantly fo the habitat value of the community.

The hard bottom faunal community at Clinton was generally more diverse than that at Black Ledge, again due to the overwhelming dominance of mussels at the latter site. As a result, although population densities were higher at Clinton, the amount of living biological material was greater at Black Ledge. In both cases, however, the rock communities supported far greater standing stocks than the surrounding soft bottoms, and it is expected that, for equivalent area, the surface of an artificial rock breakwater at Clinton would also be far more productive and ecologically valuable than the soft-bottom it would replace.

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APPENDIX 1

Faunal Raw Data, June, 1982

	2-1	2-2	5-1	5-2	6-1	6-2	7-1	7-2	9-1	9-2	10-1	10-2	11-1	11-2	15-1
ANNELIDA															
Scolecolepides viridis			109	48	92	128	1		1	25	3	17	714	462	132
Tharyx acutus		2	1	6	3	10	10	4	29	12	15	40	13	13	2
Oligochaeta									28	26	22	29	1	1	14
Asabellides oculata			2	2	7	11	21	2	1				4		
Harmothoe imbricata	2	2										10			
Streblospio benedicti	8	3		2	143	73	46	21		15	19	121	2		
Glycera americana			2	1	3		1				2	2	5	1	3
Mediomastus ambiseta	4	7			8	8	36	5			8	2			
Syllinae/Eusyllinae			2	2					39		34	44		2	
Prionospio steenstrupi	6	10			4	4	2	1	32						
Polygordius spp.		1	70	71	2	2	1								17
Exogone sp.			1							4			1		
Autolytus sp.			1				1						1		2
Polydora aggregata															
Sabellaria vulgaris															
Nereis pelagica															
Spiophanes bombyx		3			1	5							1		
Autolytus cornutus	1														
Paraonis fulgens			1						136	194	6		2		
Fabricia sabella															
Marphysa sanguinea															
Odontosyllis sp.							1			55					
Aricidea catharinae						5							71	30	1
Nephtys picta	4				14	47				3					
Phyllodocidae								1							1
Eteone heteropoda			1						20	13	6	65			
Polycirrus eximius															
Nephtys incisa		5					6	4							
Nephtydae			3	2					1				1		
Potamilla reniformis															
Anaitides groenlandica															
Orbiniidae				1								2			1
Pista palmata															
Autolytus fasciatus															
Maldanidae							9								
Sabella microphthalma															

	2-1	2-2	5-1	5-2	6-1	6-2	7-1	7-2	9-1	9-2	10-1	10-2	11-1	11-2	15-1
Archiannelida										3					187
Capitella capitata									1						
Polydora ligni				1											
Eumida sanguinea															
Parapionosyllis longicirrata															
Eteone lactea															1
Nicolea venustula															
Nereis sp.										1		10			1
Clymenella torquata							1			3					
Pygospio elegans			1									1011			
Pholoe minuta					1										
Polydora commensalis															
Lepidonotus squamatus															
Ampharetidae	4									3					
Nereidae															
Aricidea cerruti						2							7		
Polychaeta unid.															
Cirratulidae															
Hydroides dianthus															
Drilonereis longa						1									
Spionidae									1						
Dodecaceria corali															
Capitellidae									1						
Peloscolex benedeni											1				
Sphaerodoropsis minuta			1												
Potamilla sp.															
Sigalionidae							1								
Hesionidae										1					
Scoloplos acutus	2														
Dorvilleidae															1
Cirratulus grandis	3														
Anaitides mucosa															
Polydora caulleryi															
Nereis arenaceodonta															
Spio filicornis						2									

	2-1	2-2	5-1	5-2	6-1	6-2	7-1	7-2	9-1	9-2	10-1	10-2	11-1	11-2	15-1
<u>MOLLUSCA</u>															
Tellina agilis	19	8	30	13	60	55	51	18	10	9	19	6	6	7	13
Mytilis edulis		2					1								
Gemma gemma				1	1		1		19	23	39	33	3	11	12
Lacuna vincta															
Mitrella lunata									1			2			
Nassarius trivittatus	2							2					2	1	
Crepidula fornicata															
Littorina littorea															
Petricola pholadiformis															
Urosalpinx cinerea															
Anachis translirata															
Crepidula plana		1													
Mulinia lateralis							1								1
Onchidoris aspera															
Bittium alternatum									1						
Hiatella arctica															
Nucula annulata		3					2								
Anomia simplex															
Nucula delphinodonta	1														
Anomia aculeata															
Turbonilla elegantula					1										
Lunatia sp.															
Spisula solidissima		1													
Margarites umbilicalis															
Anadara transversa															
Gastropoda															
Ilyanassa obsoleta											2				
Odostomia gibbosa															
Turbonilla nivea							1								
Corambella sp.															

	2-1	2-2	5-1	5-2	6-1	6-2	7-1	7-2	9-1	9-2	10-1	10-2	11-1	11-2	15-1
CRUSTACEA															
Jassa falcata	1	14	74	23	12	4	3	2	25	33	8	26	16	8	11
Corophium bonelli	2	1	5	5	1	12	1		2		2	4		2	2
Corophium acutum	1	1	6	5	1		1		5	3			1	2	2
Marinogammarus stoerensis		3	4	1	6	5	4		1					1	1
Calliopius laevisculus		3		1		1			1	1		2			
Balanus improvisus															1
Caprella penantis															
Neopanope sayi															
Aeginina longicornis										1					
Erichsonella filiformis															
Erichthonius brasiliensis															
Idotea balthica															
Ostracoda				1					1	15				1	10
Pagurus longicarpus													1	3	
Leucon americanus		1			1	1									
Idotea phosphorea								1							
Unciola serrata															
Edotea triloba						2									
Leptochelia savignyi										2					1
Corophium simile															
Paraphoxus spinosus															
Trichophoxus epistomus															5
Oxyurostylis smithi														1	
Cancer irroratus															
Elasmopus levis															
Phoxichilidium femoratum															
Gammarus oceanicus															
Cyathura polita										1					
Phoxocephalus holbolli															
Monoculodes edwardsi															1
Caprellidae															
Decapoda															
Jaera marina															
Pseudoleptocuma minor					1										
Libinia dubia															
Tanystylum orbiculare															

	2-1	2-2	5-1	5-2	6-1	6-2	7-1	7-2	9-1	9-2	10-1	10-2	11-1	11-2	15-1
Unciola irrorata					4	1	3	1							
Pycnogonida										1					
Stenothoe minuta															
Photis sp.															
Ampelisca abdita										1					
Cumacea										1					
Proboloides holmesi														1	
<u>ECHINODERMATA</u>															
Amphipholis squamata										1					
<u>MISCELLANEOUS</u>															
Nemertea					1			1							5
Metridium senile															
Turbellaria										1					
Euplana gracilis															
Sipunculoidea															

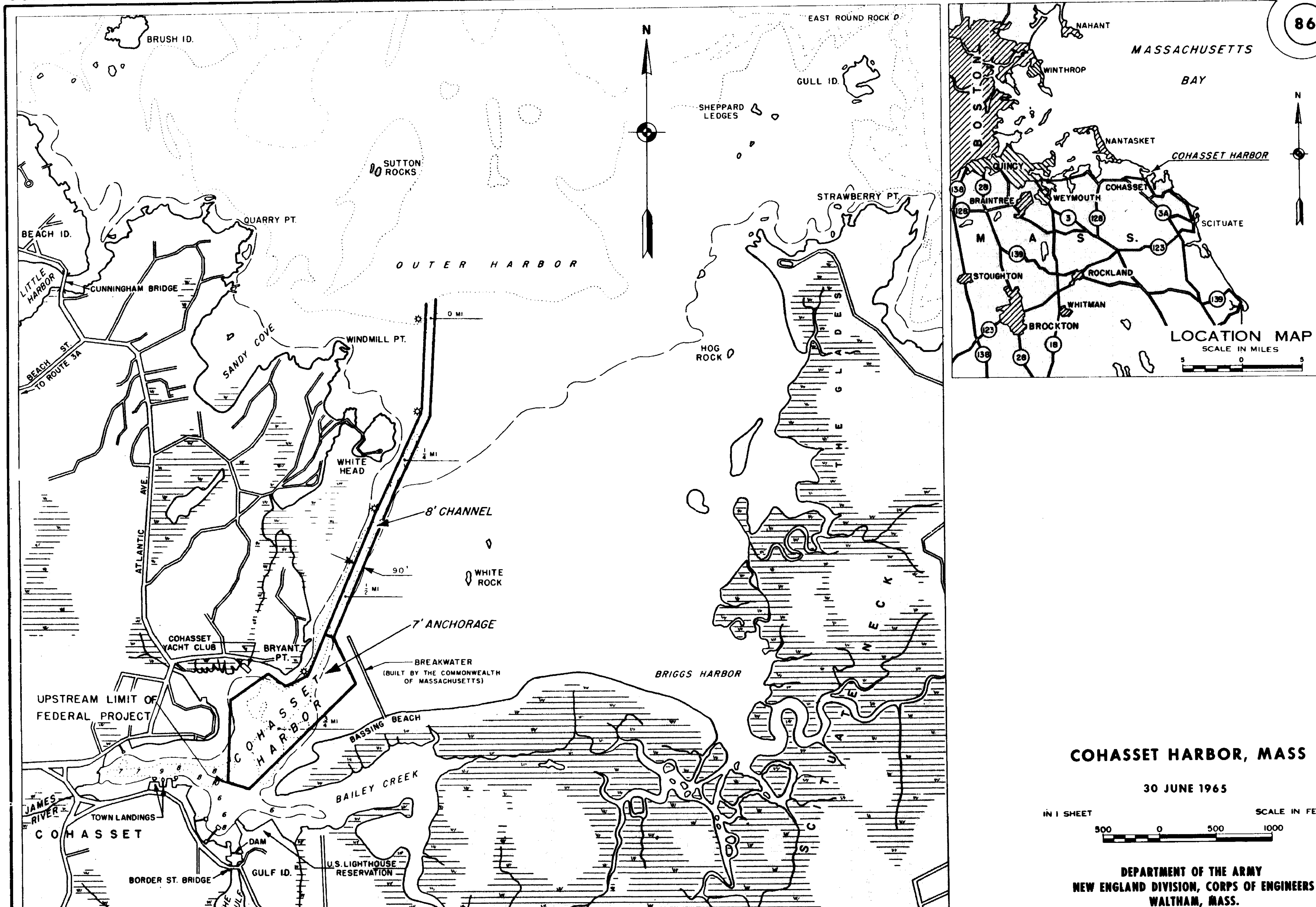
	15-2	16-1	16-2	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2	E-1	E-2	F-1	F-2
ANNELIDA															
Scolecolepides viridis	36	1	1							2		16			
Tharyx acutus		39	34												
Oligochaeta	2	12	9	1			4	12							
Asabellides oculata		9	4	1			1					8	28		
Harmothoe imbricata				87	62	68	89		8	20	36	600	882	25	20
Streblospio benedicti		52	24												
Glycera americana	1						1								
Mediomastus ambiseta		13	3												
Syllinae/Eusyllinae		2	1	2											
Prionospio steenstrupi		26	12												
Polygordius spp.	6	1													
Exogone sp.		1				2	6					12	36		
Autolytus sp.		1		6								3			
Polydora aggregata				160	124		26	8	4	4				12	
Sabellaria vulgaris		1		6		48	13						20	3	12
Nereis pelagica				18	14		6	8	4	18	8	4			
Spiophanes bombyx	2	1													
Autolytus cornutus						3	1					96	176	1	
Paraonis fulgens						1									
Fabricia sabella				5	16		2	148		10					
Marphysa sanguinea				1		6	8					8		3	
Odontosyllis sp.						8						164	148		
Aricidea catharinae												4			
Nephtys picta	5														
Phyllodocidae							1						8		1
Eteone heteropoda															
Polycirrus eximius				2	2		19						8		
Nephtys incisa			1												
Nephtydae		1													
Potamilla reniformis						2	1					12	16		
Anaitides groenlandica							1					12	4		
Orbiniidae															
Pista palmata				1		3							240		
Autolytus fasciatus							6					16	20		
Maldanidae							1						28		
Sabella microphthalma							3					24	60		

	15-2	16-1	16-2	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2	E-1	E-2	F-1	F-2
Archiannelida	119														
Capitella capitata		1		1											
Polydora ligni						15							8		
Eumida sanguinea							1						8	1	
Parapionosyllis longicirrata							3					16	32		
Eteone lactea		1													
Nicolea venustula							14					32			
Nereis sp.															
Clymenella torquata															
Pygospio elegans															
Pholoe minuta												4			
Polydora commensalis													12		3
Lepidonotus squamatus							16					20			
Ampharetidae															
Nereidae													4		
Aricidea cerruti															
Polychaeta unid.							1					12			
Cirratulidae					2										
Hydroides dianthus						2									
Drilonereis longa															
Spionidae															
Dodecaceria corali							1								
Capitellidae					4										
Peloscolex benedeni															
Sphaerodoropsis minuta															
Potamilla sp.															
Sigalionidae															
Hesionidae															
Scoloplos acutus															
Dorvilleidae															
Cirratulus grandis															
Anaitides mucosa														1	
Polydora caulleryi															
Nereis arenaceodonta															2
Spio filicornis															

	15-2	16-1	16-2	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2	E-1	E-2	F-1	F-2
MOLLUSCA															
Tellina agilis	19	7	3			3	2			2		80	120	3	
Mytilis edulis				203	338	45	10	584	232	290	180	4	88	2	6
Gemma gemma	2	1													
Lacuna vincta				270	152	355	390	60	76	110	144	240	120	64	106
Mitrella lunata						64	98	4		40	8	488	232	126	139
Nassarius trivittatus				1										3	15
Crepidula fornicata				6		2	5						4	3	23
Littorina littorea				5	20	29	15							27	50
Petricola pholadiformis					2	2	1			4	4				
Urosalpinx cinerea						3	3				4			14	17
Anachis translirata						4	1					56	56	1	
Crepidula plana				4								16		1	
Mulinia lateralis	3														
Onchidoris aspera						5	1								3
Bittium alternatum							1						4		
Hiatella arctica					4		2	4							
Nucula annulata															
Anomia simplex						1								1	
Nucula delphinodonta													8		
Anomia aculeata							5								
Turbonilla elegantula															
Lunatia sp.								16							
Spisula solidissima															
Margarites umbilicalis								4							
Anadara transversa												4			
Gastropoda												4			
Ilyanassa obsoleta															
Odostomia gibbosa													20		
Turbonilla nivea															
Corambella sp.													4		

	15-2	16-1	16-2	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2	E-1	E-2	F-1	F-2
CRUSTACEA															
Jassa falcata	13	34	11	405	1284	650	420	12456	6096	1844	1232	180	76	13	72
Corophium bonelli	3	6		113	316	27	32	456	128	68	96	4	12	3	1
Corophium acutum	1	9	1	191	348	78	301	608	608	320	600	84	744	35	12
Marinogammarus stoerensis		1	2	2	24			32	16	28	8	20	4		4
Calliopius laevisculus			2	6	72	7	4	344	96	136	64		4	9	6
Balanus improvisus				7302	11136	1718	161	13836	4056	1668	4658			118	465
Caprella penantis							10	104	12	34	52	12	32		
Neopanope sayi						14	2		4		4		49	3	2
Aeginina longicornis		1					1			8		40	32	1	
Erichsonella filiformis						4	3				4	56	84	1	
Erichthonius brasiliensis						3	2					76	56	1	7
Idotea balthica						1	2	36	4		2				5
Ostracoda		5													
Pagurus longicarpus						1								8	7
Leucon americanus		4	2												
Idotea phosphorea				1											1
Unciola serrata				1		8	8								
Edotea triloba		1											4		
Leptochelia savignyi												4			
Corophium simile				1									4		
Paraphoxus spinosus													4	1	
Trichophoxus epistomus	9														
Oxyurostylis smithi			1												
Cancer irroratus						2				2					
Elasmopus levis						6	1						24		
Phoxichilidium femoratum															
Gammarus oceanicus							2								
Cyathura polita															
Phoxocephalus holbolli										2					
Monoculodes edwardsi															
Caprellidae	1														
Decapoda												8			
Jaera marina					2										
Pseudoleptocuma minor															
Libinia dubia													8		
Tanystylum orbiculare													8		

	15-2	16-1	16-2	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2	E-1	E-2	F-1	F-2
Unciola irrorata															
Pycnogonida															
Stenothoe minuta													28		
Photis sp.				1											
Ampelisca abdita															
Cumacea															
Proboloides holmesi															
<u>ECHINODERMATA</u>															
Amphipholis squamata															
<u>MISCELLANEOUS</u>															
Nemertea				1	8		9					12	28		
Metridium senile							1			2	2	48	60		
Turbellaria		6						8							
Euplana gracilis												4			
Sipunculoidea										2					



COHASSET HARBOR, MASS

30 JUNE 1965

IN 1 SHEET

SCALE IN FEET

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.